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AIR QUALITY THUNDER BAY

Annual Report, 1978



Ontario

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AIR QUALITY

THUNDER BAY

Annual Report, 1978

TECHNICAL SUPPORT SECTION
NORTHWESTERN REGION
ONTARIO MINISTRY OF THE ENVIRONMENT
October, 1979

CONTENTS

SUMMARY	1
INTRODUCTION	2
PARTICULATE POLLUTANTS	2
DUSTFALL	2
SUSPENDED PARTICULATE	4
SOILING INDEX	5
GASEOUS POLLUTANTS	6
SULPHATION RATES	6
SULPHUR DIOXIDE	6
TOTAL REDUCED SULPHUR	8
SPECIAL SURVEYS	8
ABITIBI	8
GREAT LAKES FOREST PRODUCTS	9
THUNDER BAY TERMINALS	9
THUNDERBRICK LIMITED	10
REFERENCES	11
FIGURES AND TABLES	12-28

SUMMARY

Air quality studies in Thunder Bay, begun by the Ontario Ministry of the Environment in 1963, continued in 1978 with a programme which included monitoring the levels of several pollutants throughout the city, as well as special surveys conducted around selected local industries.

Average dustfall in 1978 complied with the Ontario objective at all but three of 16 sites. The overall average for Thunder Bay was lower in 1978 than in 1977, continuing a trend of decline in which average dustfall for the city has decreased by 35 percent from 1973 to 1978. For the first time since monitoring began, concentrations of suspended particulate matter (fine dust) at all seven monitoring locations met the annual objective. Annual averages have dropped about 40 percent in the past 6 years. These significant improvements in dustfall and suspended particulate were largely attributed to the \$40 million dust control programme which, by the end of 1978, was about 95 percent complete at Thunder Bay's 14 grain elevators.

Concentrations of heavy metals in suspended particulate were consistently below the maximum levels permitted under Ontario regulations. Soiling index, a measure of the soiling properties of dust, was also well within provincial objectives.

Average sulphation rates, which provide a rough estimate of the presence of sulphur-containing gases, were acceptable throughout the city. There were only two excursions above the maximum acceptable limit for 1-hour sulphur dioxide concentrations at seven Ministry and Ontario Hydro monitoring stations. The daily and annual objectives for sulphur dioxide were consistently met. TRS (total reduced sulphur), responsible for objectionable odours near kraft pulp mills, moderately exceeded the Ontario guideline on 28 occasions (17 in 1977) at a monitoring site near Great Lakes Forest Products Limited.

INTRODUCTION

A permanent air quality monitoring programme was first established in Thunder Bay in 1963, with a single sampler at 14 Algoma Street. Since then, the Ministry has developed an instrument network at 17 sites in the city. In 1978, the monitoring network included 2 sulphur dioxide analysers, a total reduced sulphur monitor, 2 soiling index instruments, 7 high-volume samplers, 16 dustfall jars and 13 sulphation plates. Ontario Hydro also operated five sulphur dioxide monitors in Thunder Bay to record air quality in the vicinity of its thermal generating station on Mission Island.

Special air quality surveys were carried out in 1978 near specific Thunder Bay industries including the pulp mills (Abitibi and Great Lakes Forest Products), the coal terminal on McKellar Island (Thunder Bay Terminals Limited) and a brick plant in Rosslyn (Thunderbrick Limited). This report provides brief summaries of results from these studies, each of which is fully described in separate reports.

PARTICULATE POLLUTANTS

DUSTFALL

Dustfall, which comprises particulate matter that settles out from the atmosphere by gravity, has been monitored in Thunder Bay since 1970. The method of measurement is described in earlier air quality reports (1, 2, 3). All dustfall analyses were performed at the Ministry's Thunder Bay laboratory.

In 1978, dustfall from 16 sites (Figure 1) was analysed for soluble sulphate. Soluble calcium, chloride and sulphate were also determined in dustfall at stations 63046 and 63047, near Great Lakes Forest Products Limited.

Total dustfall (Table 1) exceeded the 30-day objective at least once at 6 of 16 sites. However, average annual dustfall complied with Ontario regulations at all but three locations (four in 1977). Dustfall levels were usually highest near grain elevators. Soluble sulphate constituted less than $1 \text{ g/m}^2/30 \text{ days}$ (1 gram of sulphate per square metre for 30 days), with highest average sulphate concentrations occurring in dustfall at sites near Great Lakes Forest Products. Since most sulphate values in Thunder Bay were consistently low during the past 3 years, dustfall analysis for sulphate was discontinued at all but three sites at the end of 1978. Soluble calcium, chloride and sodium were also very low ($<0.5 \text{ g/m}^2/30 \text{ days}$) in dustfall at stations 63046 and 63047 and further analysis of these elements was terminated at the end of the year.

In 1976 and 1977, grain dust was the dominant constituent in insoluble dustfall at two monitoring locations near grain elevators (2, 3). At two non-industrial sites, road dust was the most important contaminant identified. It was not possible to arrange for a similar analysis of 1978 samples.

Average dustfall for 13 locations is compared, in Table 2 and in Figures 2, 4a and 4b, for the 6-year period from 1973 to 1978. The trend of decreasing dustfall levels is very evident, and average dustfall for the city has complied with the Ontario air quality objective since 1976. There was an overall 35 percent reduction in dustfall from 1973 to 1978.

The relationships between average dustfall, season of the year, and prevailing wind direction were the same in 1978 as reported for preceding years. Dustfall in spring and summer (5.7 and $4.7 \text{ g/m}^2/30 \text{ days}$, respectively) was higher than that measured in the fall and winter (2.7 and 2.6 g/m^2 , respectively). Also, average dustfall with easterly prevailing wind was, at $5.2 \text{ g/m}^2/30 \text{ days}$, double the value for westerly wind directions.

Compared to other urban centres in Ontario, dustfall in 1978 in Thunder Bay was similar to the average recorded in Sudbury or Sault Ste. Marie, and significantly lower than dustfall in industrial cities such as Hamilton or Windsor.

SUSPENDED PARTICULATE

Suspended particulate, comprising dust particles of small size, is measured with a high-volume sampler for a 24-hour period every sixth day. A measured volume of air is drawn through a fibreglass filter which is weighed before and after the sampling period. The difference in filter weight determines the total quantity of dust collected. Sample filters from two Thunder Bay monitoring sites are also routinely analysed for nitrate, sulphate and a range of heavy metals.

Total suspended particulate (TSP) occasionally exceeded the provincial 24-hour objective at all seven sites in 1978 (Table 3). About 6 percent of the samples were over the daily objective of $120 \mu\text{g}/\text{m}^3$ (micrograms of particulate matter per cubic metre of air), and the maximum value was $280 \mu\text{g}/\text{m}^3$. However, for the first time since monitoring began in 1963, the annual averages met the Ontario objective at all locations. Because suspended particulate is more of a health-related contaminant than dustfall, this achievement is considered significant. Average suspended particulate levels declined from $70 \mu\text{g}/\text{m}^3$ in 1973 to $42 \mu\text{g}/\text{m}^3$ in 1978, a drop of about 40 percent. This trend is illustrated by the data in Table 4 and by the bar graph in Figure 3. The 1978 levels for Thunder Bay were similar to those for Ottawa and Sudbury and much lower than averages reported for Sarnia, Toronto, Windsor and Hamilton. The occurrence of highest TSP in the spring and summer, and lowest levels in the fall and winter followed the same pattern reported for dustfall.

The improvement in dustfall and suspended particulate concentrations in recent years is attributed to the major dust control programme implemented at the 14 operating grain elevators in Thunder Bay. These abatement projects, involving expenditure of more than \$40 million to achieve a 95 percent reduction in dust emissions, were nearly complete at the end of 1978 and will be fully operational within 2 to 3 years. Since the principal industrial sources of dust emissions are now largely controlled, the Ministry does not expect further significant reductions in average dustfall or suspended particulate levels.

Concentrations of heavy metals, nitrates and sulphates in suspended particulate are reported in Table 5. The levels of all these contaminants were well below the maximum acceptable values prescribed in Ontario regulations. Average nitrate and sulphate concentrations continued to be lower than those found in most Ontario communities (4).

SOILING INDEX

Soiling index is a measurement of the soiling or darkening properties of suspended particulate matter. An advantage of the method, described in our 1977 report (3), is that data are produced continuously and automatically rather than intermittently as with a high-volume sampler.

Readings of soiling index in 1978 (Table 6) were similar to those for 1976 and 1977. Levels at the two Thunder Bay monitoring sites were all within the provincial regulations of 1.0 COH (coefficient of haze) for 24 hours, or 0.5 COH, annual average.

GASEOUS POLLUTANTS

SULPHATION RATES

A semi-quantitative estimate of average levels of sulphur-containing gases in the atmosphere is obtained by exposing lead dioxide-coated plastic dishes to the air for specified periods. The method, based on the chemical conversion of lead dioxide to lead sulphate, does not discriminate between different reactive sulphur compounds. Readings are obtained when any such pollutant is present in sufficient concentration. Results may also be strongly influenced by variations in temperature, wind speed and humidity.

Sulphation rates for 1978 (Table 7) were generally similar to those for earlier years. Values at most locations were very low and were typical of areas where sulphur-containing pollutants do not pose a problem. Except for 1977, average sulphation rates for the city have been very stable in recent years (Table 8). The abnormal result for 1977 may have reflected the effects of an increased level of operations, and hence greater sulphur dioxide emissions, from Ontario Hydro's generating station that year.

Because of the uncertainties in interpreting sulphation rate data, and because there is now in place a good network of continuous sulphur dioxide and reduced sulphur monitors in Thunder Bay, sulphation rate measurements were terminated in December.

SULPHUR DIOXIDE

Sulphur dioxide (SO_2) is one of the world's major atmospheric pollutants and has many well-known adverse effects on human health, plant life and property. The principal industrial sources of SO_2 in Thunder Bay are the Ontario Hydro generating

station, the sulphite paper mills, and some industrial power boilers. Total emissions for all city sources are, however, quite small and do not exceed 100 metric tons per day.

The Ministry operated two continuous analysers (Philips models 9700 and 9755) at three stations in 1978. The Dawson Court monitor (station 63012) was transferred to St. Joseph's Hospital (63022) in mid-year, following the termination of sulphite pulping operations at Abitibi's Provincial mill on June 30. Ontario Hydro ran instruments of the same type at five other locations in the city. Toward the end of the year, Ontario Hydro began to alter their monitoring network to take account of the expansion of the Thunder Bay generating station, scheduled for completion in late 1981.

The Ministry's monitors recorded acceptable concentrations of sulphur dioxide throughout the city. Maximum and mean levels (Table 9) were very similar to those in 1977. The highest 1-hour average at any location in 1978 was 0.19 ppm (parts per million), compared to the maximum acceptable limit of 0.25 ppm. All "significant" readings of SO_2 (those of 0.10 ppm, or more) at the Dawson Court site were attributed to emissions from Abitibi's Provincial Mill. "Significant" hourly averages at the monitor at 435 James Street were due to SO_2 from Ontario Hydro's generating station. Sulphur dioxide levels at the St. Joseph's Hospital station, which operated for the last half of the year, were very low.

Two excursions above the 1-hour objective were reported by Ontario Hydro (Table 10), one of 0.29 ppm on Walsh Street on May 6 and one of 0.37 ppm on Mt. McKay on May 7. The first incident was probably due to emissions from Ontario Hydro's plant and the second to SO_2 from Great Lakes Forest Products. The daily and annual objectives were met at all monitoring locations.

TOTAL REDUCED SULPHUR

Total reduced sulphur, or TRS, constitutes a group of sulphur-containing gases which are commonly associated with emissions from kraft pulp mills. Their presence in the air at even very low levels creates offensive odours. Higher concentrations may darken lead-based paint, cause vegetation injury, or result in temporary health effects such as respiratory irritation. In 1978, the Ministry monitored TRS at station 63046, about 1100 m (metres) from the Great Lakes Forest Products Limited kraft pulp mill. The analyser at this location was of the coulometric titration type (Philips model 9700), which responds to hydrogen sulphide, methyl and ethyl mercaptan and dimethyl sulphide. The operating range was set at about 0-250 ppb (parts per billion), with a detection limit of about 2 ppb.

The summary of TRS concentrations for 1978 are given in Table 11 and plotted in Figure 5. Excursions above the Ontario guideline of 27 ppb (parts per billion, hourly average) occurred 28 times during the year, and the maximum value was 48 ppb. In 1977, there were 17 excursions above the guideline and a maximum concentration of 56 ppb. An analysis of TRS and wind directions (Table 12) confirmed that Great Lakes Forest Products was the source of virtually all TRS odours recorded at the Ministry's monitor.

SPECIAL SURVEYS

ABITIBI

Vegetation assessment surveys, conducted since 1975, have documented the occasional occurrence of visible sulphur dioxide injury symptoms on vegetation near Abitibi's sulphite pulp

mills in Thunder Bay (3). Damage has been restricted to company property. In 1978, an inspection around the three mills revealed no evidence of any local vegetation damage caused by sulphur dioxide.

GREAT LAKES FOREST PRODUCTS

In late 1977, an air quality survey with mobile monitoring equipment was undertaken by the Ministry's Air Resources Branch in the vicinity of Great Lakes Forest Products Limited. The results of this study (5), released in mid-1978, showed that TRS levels sometimes exceeded the Ontario guideline. A few readings of suspended particulate and one value for sulphur dioxide also exceeded provincial standards. The report on a follow-up investigation in the summer of 1978 is not yet available.

In February, 1978, the Ministry's regional office collected snow from 24 sites around the Great Lakes mill. This study (6) showed that calcium, sodium and sulphate were well above Ministry guidelines in snow near the mill. The company's waferboard plant and power boiler stacks were identified as sources of particulate emissions (sawdust and bark char, respectively). None of the contaminants, at the levels found, were considered a threat to public health. A later study, in June, showed that *Sphagnum* moss experimentally exposed near the mill picked up significant quantities of calcium, but very little chloride or sodium. A separate report on this investigation will be prepared in due course.

THUNDER BAY TERMINALS

Pre-operational air and water quality monitoring in the vicinity of the Thunder Bay Terminals project on McKellar Island has been routinely carried out since 1975 by the Ministry of the Environment and by the company's consultants. A summary

of the data, up to the end of 1976, appeared in a joint air and water quality monitoring report (7). The findings for air quality in 1977 (8) were similar to those for earlier years. The report for 1978, expected in late 1979, will for the first time include data for the initial post-operational period following start-up of the coal terminal in mid-June.

THUNDERBRICK LIMITED

Ministry investigations have shown that airborne fluoride emissions from the Thunderbrick Limited plant in Rosslyn pose a potential threat to sensitive vegetation on nearby residential properties (9). Fluoride levels were often well above the Ontario guideline in tree foliage, both on and off company property. Monthly fluoridation rates, measured by lime candles, also frequently exceeded maximum acceptable limits. There was no evidence of fluoride levels which would be hazardous to human health. The Ministry and Thunderbrick are now considering what abatement measures are feasible. Further monitoring is being carried out in 1979.

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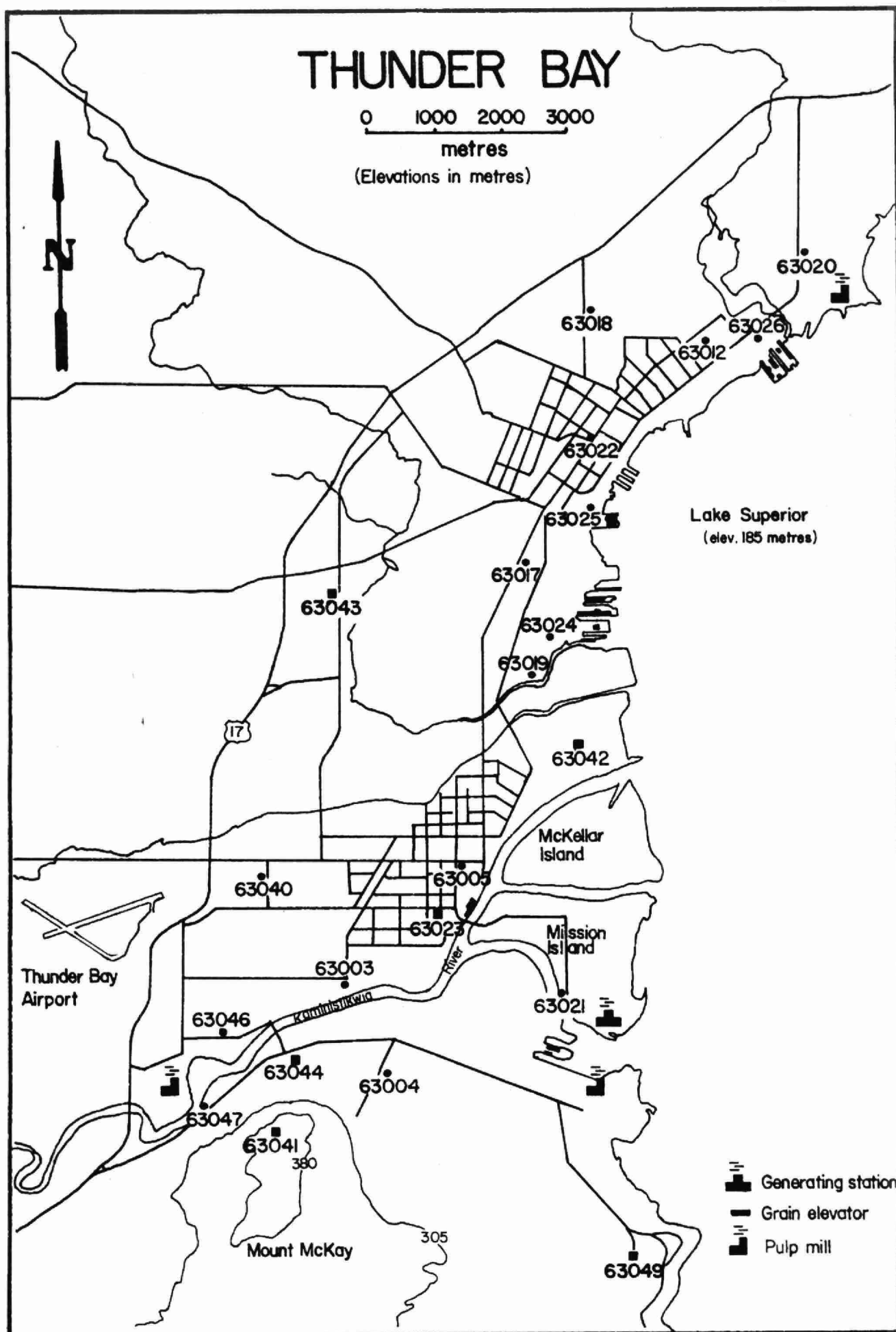


Figure 1. Air quality monitoring sites, 1978.

(■ Ontario Hydro sites)

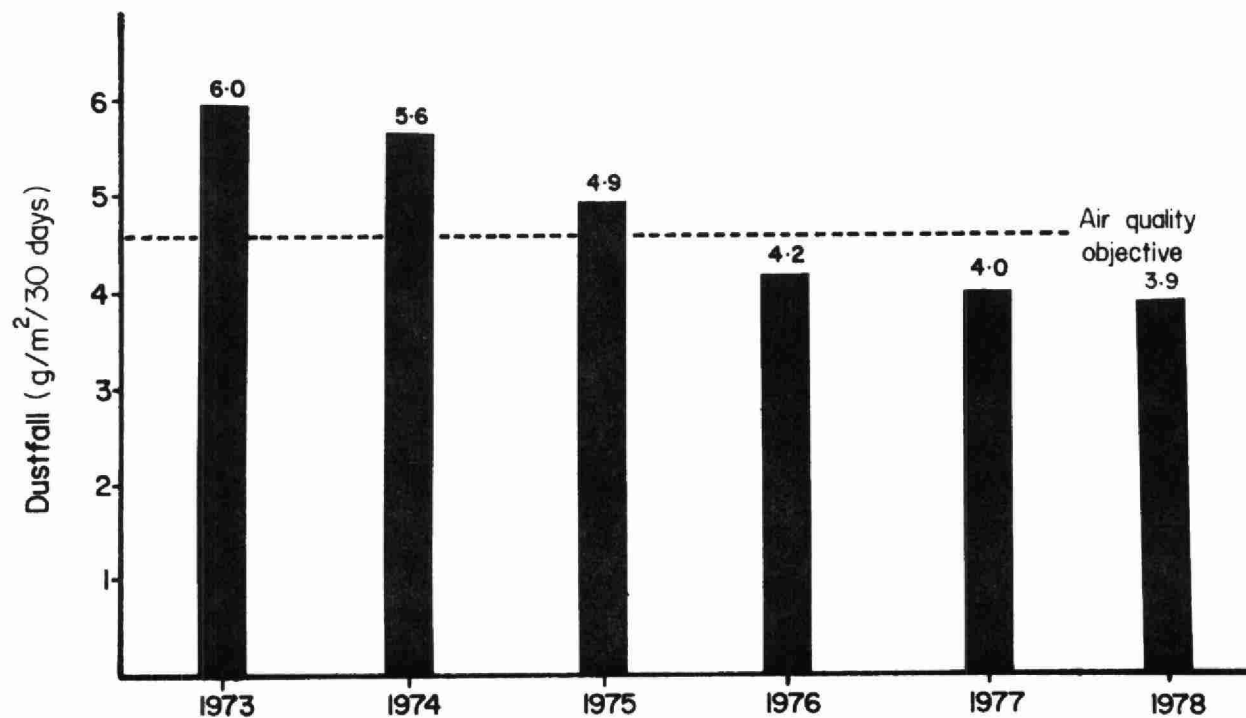


Figure 2. Average annual dustfall, 1973-1978, Thunder Bay.

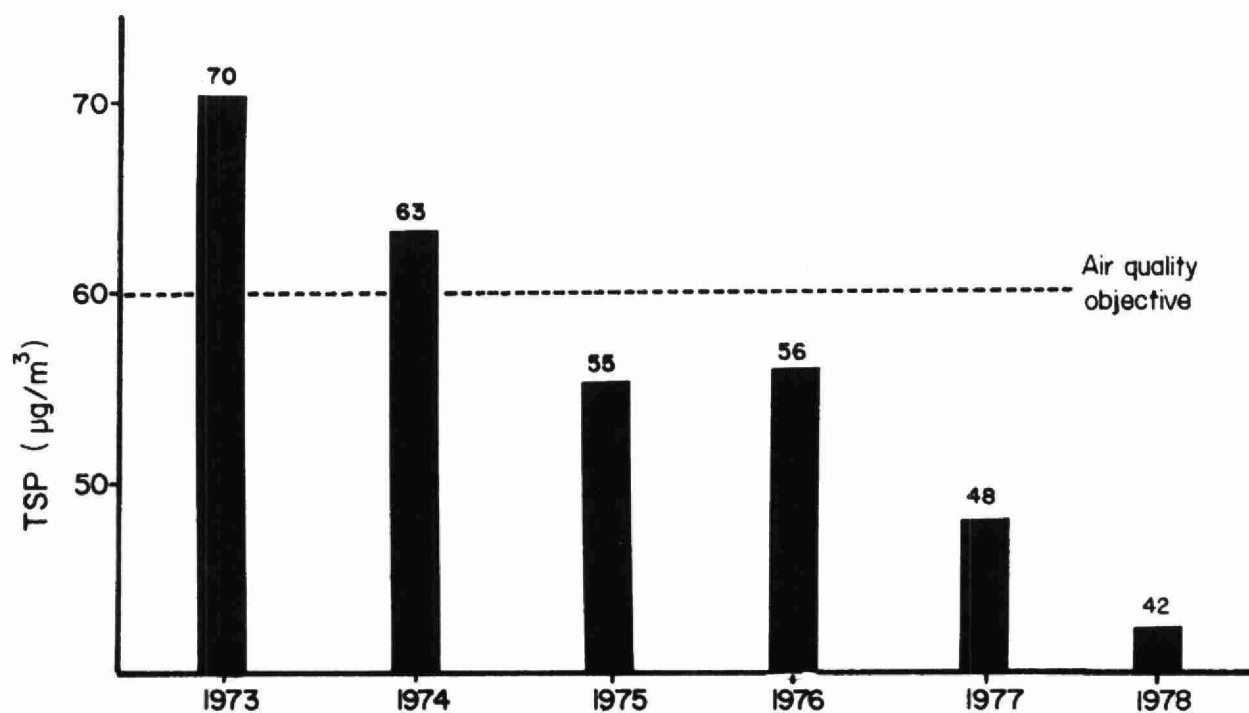


Figure 3. Average total suspended particulate (TSP), 1973-1978, Thunder Bay.

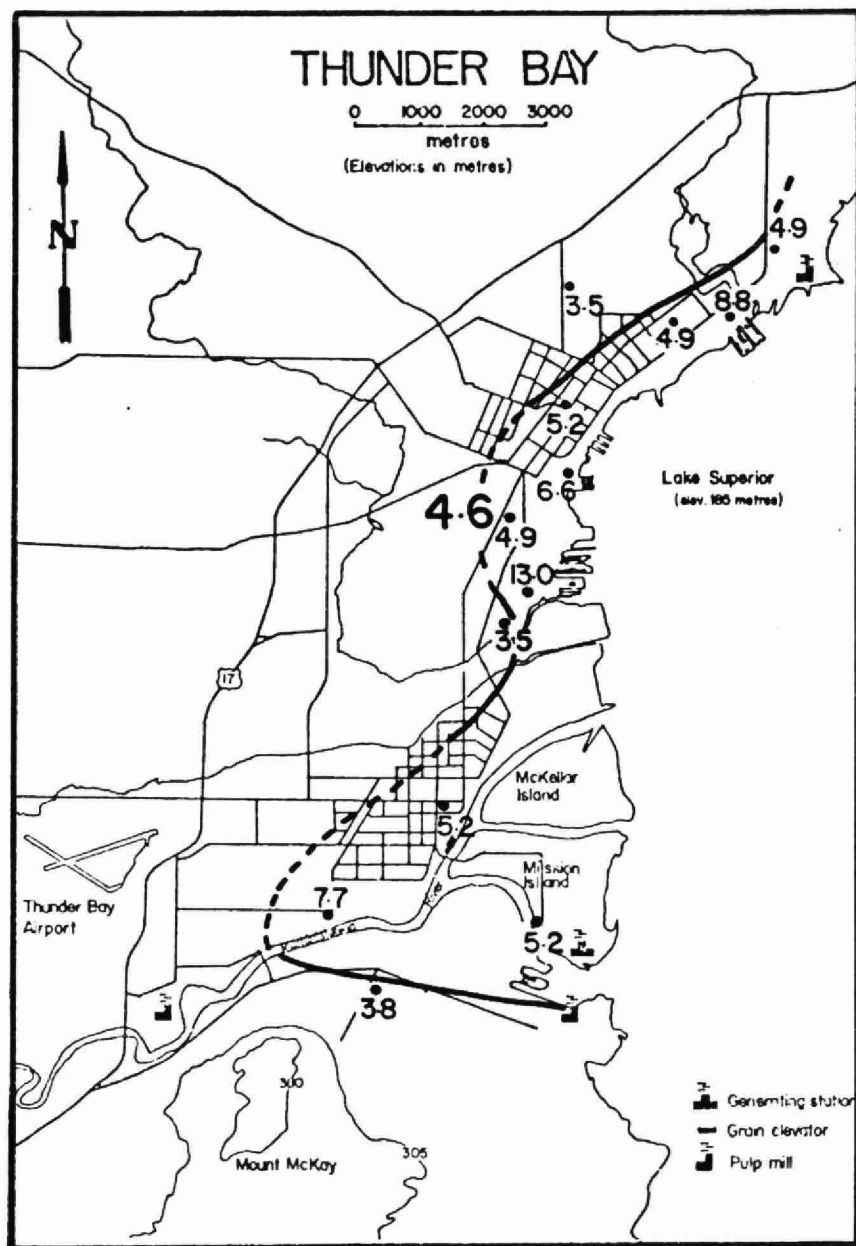


Figure 4 a. Average dustfall, 1973 ($\text{g}/\text{m}^2/30$ days).

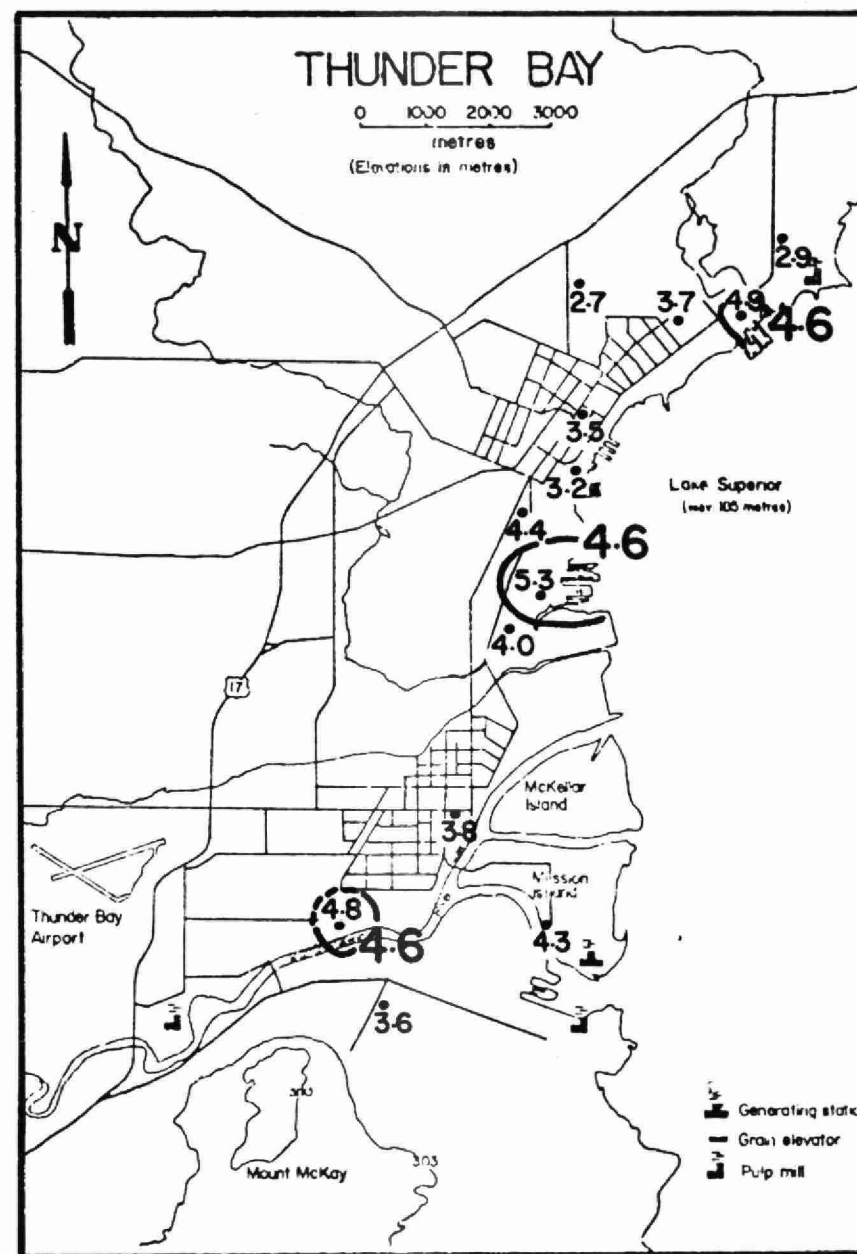


Figure 4b. Average dustfall, 1978 ($\text{g}/\text{m}^2/30$ days).

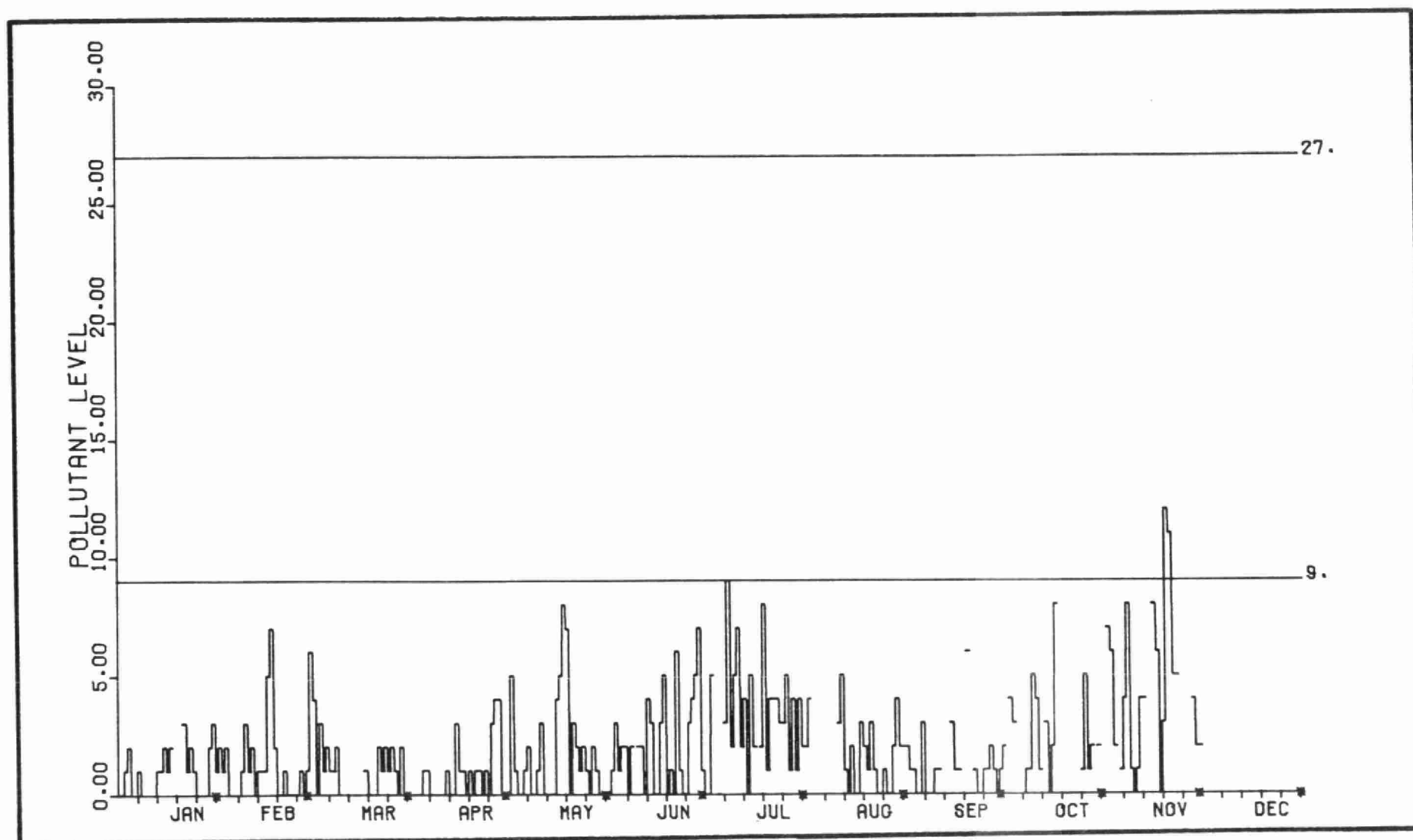


Figure 5. Daily mean TRS concentrations (parts per billion), station 63046, Thunder Bay.

TABLE 1. Total dustfall ($\text{g/m}^2/30$ days), Thunder Bay, 1978.

Station	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
63003	185 Gore Street	3.1	1.7	3.5	<u>8.8</u> ^a	5.9	<u>7.2</u>	6.4	<u>7.2</u>	4.7	4.4	2.1	2.0	<u>4.8</u>
63004	24 Mountain Road	3.6	1.8	2.2	3.6	6.2	<u>9.1</u>	3.9	3.3	5.0	2.7	1.0	1.1	3.6
63005	McKellar Hospital	1.4	2.0	3.5	<u>7.6</u>	6.5	5.5	3.5	5.1	3.3	3.0	1.7	2.8	2.8
63012	Dawson Court	3.1	1.4	3.0	5.7	4.8	6.6	5.5	4.1	5.0	2.6	1.3	0.8	3.7
63017	521 Memorial Avenue	2.3	4.0	5.0	-	5.9	4.4	<u>7.1</u>	4.6	5.3	5.0	3.0	1.6	4.4
63018	St. Ignatius School	0.6	1.2	3.3	4.2	-	3.1	3.3	-	2.5	2.7	1.8	1.2	2.7
63019	Main St. Sewage Plant	1.0	1.4	2.2	4.6	3.4	4.3	4.9	4.0	5.5	5.2	1.9	1.2	4.0
63020	Hodder Ave. Fire Hall	4.9	2.3	3.1	2.8	3.2	3.1	5.7	2.8	2.3	3.1	1.7	1.3	2.9
63021	Mission Island	4.8	3.9	2.1	4.3	4.3	3.8	4.6	4.9	3.8	4.3	6.7	<u>7.5</u>	4.3
63022	St. Joseph's Hospital	1.1	2.2	4.7	6.9	5.6	4.9	3.1	3.6	4.0	2.8	1.7	1.4	3.5
63024	Hammond Ave./Inter-City	0.3	2.4	3.8	<u>8.4</u>	<u>14.0</u>	<u>11.0</u>	<u>7.2</u>	<u>7.2</u>	2.9	3.7	1.5	0.8	<u>5.3</u>
63025	Manitou Street	0.3	1.8	3.3	5.5	5.1	4.5	3.9	3.9	3.1	4.0	2.6	1.0	3.2
63026	North Cumberland Hydro	1.0	2.2	4.9	6.4	7.0	<u>8.2</u>	6.2	<u>7.3</u>	5.0	3.7	4.6	2.0	<u>4.9</u>
63040	435 James St. South	0.5	1.4	2.4	4.2	5.1	5.0	6.4	3.6	3.3	2.8	2.2	1.7	3.2
63046	Montreal Street			4.3	-	5.6	4.4	4.0	6.5	5.8	5.6	5.4	3.7	
63047	Totem Trailer Court	6.4	3.1	4.3	-	4.5	-	-	6.1	4.1	2.4	1.5	1.5	3.8

^aValues exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 2. Average dustfall ($\text{g/m}^2/30$ days), Thunder Bay, 1973-1978.

Station	Location	1973	1974	1975	1976	1977	1978	Six-year average
63003	185 Gore Street	<u>7.7</u> ^a	<u>7.4</u>	4.6	4.2	<u>4.7</u>	<u>4.8</u>	5.6
63004	24 Mountain Road	3.9	3.9	3.5	3.2	3.7	3.6	3.6
63005	McKellar Hospital	<u>5.3</u>	<u>5.3</u>	<u>4.9</u>	3.5	<u>5.0</u>	3.8	4.6
63012	Dawson Court	<u>4.9</u>	<u>4.6</u>	3.5	3.5	3.6	3.7	4.0
63017	521 Memorial Ave.	<u>4.9</u>	<u>6.0</u>	<u>5.3</u>	<u>4.9</u>	<u>4.9</u>	4.4	5.1
63018	St. Ignatius School	3.5	3.5	2.5	3.2	2.0	2.7	3.1
63019	Main Street	3.5	<u>7.0</u>	3.5	4.2	3.8	4.0	4.3
63020	Hodder Avenue	<u>4.9</u>	<u>5.3</u>	<u>5.6</u>	3.5	2.8	2.9	4.2
63021	Mission Island	<u>5.3</u>	<u>5.3</u>	<u>6.7</u>	<u>5.6</u>	4.6	4.3	5.3
63022	St. Joseph's Hospital	<u>5.3</u>	<u>5.6</u>	4.2	3.9	3.7	3.5	4.4
63024	Hammond Avenue	<u>13.0</u>	<u>10.2</u>	<u>7.7</u>	<u>5.3</u>	4.4	<u>5.3</u>	7.7
63025	Manitou Street	<u>6.7</u>	4.6	4.6	3.9	3.8	3.2	4.5
63026	N. Cumberland St.	<u>8.8</u>	<u>6.7</u>	<u>6.0</u>	<u>5.6</u>	<u>4.9</u>	<u>4.9</u>	6.2
Average, all locations		6.0	5.6	4.9	4.2	4.0	3.9	
Locations exceeding objective (%)		77	69	46	31	31	23	

^aValues exceeding maximum acceptable level of 4.6 (annual average) are underlined.

TABLE 3. Total suspended particulate ($\mu\text{g}/\text{m}^3$), Thunder Bay, 1978.

Date	Monitoring stations					
	63005	63012	63017	63018	63022	63040 63046
Jan 2	15	14	16	6	12	14
8	11	10	16	-	14	-
14	43	17	49	13	24	16
20	31	20	69	29	28	26
26	17	-	29	13	15	14
Feb 2	44	34	47	33	43	29
7	30	25	29	12	22	21
13	30	34	38	21	23	34
19	62	46	67	38	63	68
25	20	14	-	16	23	16
Mar 3	-	-	-	-	-	-
9	60	48	48	28	47	37
15	27	73	42	19	42	39
21	53	23	53	-	30	36
27	67	38	52	13	48	72
Apr 2	-	27	30	42	38	62
8	54	27	49	31	55	50
14	56	35	111	-	70	36
20	69	32	86	29	52	30
26	<u>196^a</u>	<u>220</u>	<u>280</u>	<u>207</u>	<u>151</u>	<u>146</u>
May 2	115	<u>149</u>	<u>220</u>	<u>138</u>	<u>128</u>	117
8	49	<u>48</u>	<u>67</u>	<u>34</u>	<u>91</u>	43
14	26	23	38	-	23	23
20	29	17	56	-	22	22
26	106	<u>208</u>	<u>173</u>	<u>156</u>	<u>161</u>	115
Jun 1	49	64	32	26	33	36
7	44	26	71	38	31	37
13	106	95	112	89	72	51
19	<u>126</u>	62	-	108	<u>132</u>	<u>126</u>
25	<u>54</u>	51	69	42	-	48
Jul 1	-	44	52	59	75	-
7	48	54	85	11	58	-
13	35	42	84	33	43	38
19	67	85	<u>183</u>	50	72	75
25	86	108	<u>147</u>	78	92	85
31	66	40	<u>77</u>	37	45	32
						74
						73
						25

TABLE 3. Continued.

Date	Monitoring stations						
	63005	63012	63017	63018	63022	63040	63046
Aug 6	31	20	68	57	25	40	79
12	<u>130</u>	90	58	85	92	99	<u>161</u>
18	-	56	-	38	61	46	<u>70</u>
24	-	35	59	22	-	39	92
30	66	62	84	62	53	30	-
Sep 5	43	65	64	-	95	52	88
11	31	28	33	11	26	22	28
17	31	32	36	28	29	15	-
23	63	52	112	94	65	32	63
29	-	44	28	19	44	28	-
Oct 5	35	12	41	13	23	14	11
11	40	58	82	51	60	44	36
17	52	47	103	67	51	30	56
23	26	59	104	32	45	68	46
29	63	17	54	51	43	34	58
Nov 4	31	-	40	48	30	19	112
10	48	16	44	36	27	28	50
16	60	39	<u>130</u>	46	62	48	116
22	50	32	<u>63</u>	37	46	33	50
28	19	12	21	15	20	21	38
Dec 4	44	22	27	23	28	20	60
10	29	13	30	12	26	17	47
16	27	11	17	10	21	17	54
22	17	-	15	34	21	15	27
28	-	-	-	-	-	-	-
Annual geometric means:	44	37	56	33	42	35	

^aValues exceeding maximum acceptable level of 120 $\mu\text{g}/\text{m}^3$ (24-hour average) are underlined.

TABLE 4. Average concentrations ($\mu\text{g}/\text{m}^3$) of suspended particulate in Thunder Bay, 1973-1978.

Station	Location	1973	1974	1975	1976	1977	1978	Six-year average
63005	McKellar Hospital	<u>69</u> ^a	<u>61</u>	51	49	47	44	54
63012	Dawson Court	59	51	47	47	40	37	47
63017	521 Memorial Ave.	<u>107</u>	<u>102</u>	<u>85</u>	<u>82</u>	<u>69</u>	56	84
63018	St. Ignatius School	40	40	36	37	34	33	37
63022	35 Algoma Street	<u>74</u>	60	55	<u>66</u>	49	42	58
Average, all locations		70	63	55	56	48	42	
Locations exceeding objective (%)		60	40	20	40	20	0	

^aValues exceeding maximum acceptable level of $60 \mu\text{g}/\text{m}^3$ (annual geometric mean) are underlined.

TABLE 5. Concentrations ($\mu\text{g}/\text{m}^3$, 24-hour averages) of heavy metals, nitrate and sulphate in suspended particulate matter, 1978.

Contaminant	Station 63005 ^a		Station 63022 ^b	
	Range	Average	Range	Average
Cadmium	ND ^c - <0.01	<0.01	ND - <0.01	<0.01
Chromium	ND - 0.03	<0.01	ND - 0.02	<0.01
Copper	0.01 - 0.16	0.05	0.01 - 1.79	0.28
Iron	0.24 - 7.58	2.04	0.23 - 9.85	1.93
Lead	0.02 - 1.82	0.20	0.06 - 0.74	0.28
Manganese	<0.01 - 0.15	0.04	ND - 0.19	0.05
Nickel	ND - 0.22	<0.01	ND - 0.03	<0.01
Nitrate	0.20 - 4.30	1.30	0.10 - 2.70	1.10
Sulphate	1.30 - 22.50	5.10	1.80 - 20.70	4.70
Vanadium	ND - 0.03	<0.01	ND - 0.03	<0.01
Zinc	ND - 0.51	0.14	ND - 0.57	0.05

^a54 samples.

^b57 samples.

^cNot detectable.

TABLE 6. Distribution of soiling index reading (2-hour averages) in Thunder Bay, 1978.

Month	Days of data	Number of readings for COH ^a range of:				Maximum values:	
		0.0-0.5	0.5-1.0	1.0-1.5	>1.5	2-hour	24-hour
Station 63022							
Jan			no data				
Feb	6	72	6	0	0	0.7	0.2
Mar	13	146	7	1	0	1.2	0.3
Apr	17	195	15	0	1	1.7	0.2
May	31	348	24	0	0	0.9	0.3
Jun	27	319	11	0	0	0.7	0.2
Jul	18	210	5	0	0	0.5	0.2
Aug	31	353	19	0	0	1.0	0.3
Sep	25	292	17	0	0	0.7	0.2
Oct	24	277	23	0	0	0.9	0.3
Nov	30	330	28	0	0	0.8	0.3
Dec	27	290	38	0	0	1.0	0.5
Year	249	2832	193	1	1	1.7	0.5
Station 63040							
Jan	25	278	16	1	0	1.5	0.4
Feb	28	326	9	1	0	1.1	0.2
Mar	29	347	15	0	0	0.7	0.3
Apr	26	298	17	0	0	0.7	0.3
May	31	351	20	0	0	0.9	0.4
Jun	28	346	3	0	0	0.9	0.2
Jul	31	364	8	0	0	0.7	0.2
Aug	31	355	16	0	0	0.7	0.3
Sep	30	353	7	0	0	0.8	0.2
Oct	28	330	6	0	0	0.7	0.2
Nov			no data				
Dec			no data				
Year	287	3348	117	2	0	1.5	0.4

^aCOH = Coefficient of haze per 1000 linear feet of air.

TABLE 7. Sulphation rates ($\text{mg SO}_3/100 \text{ cm}^2/\text{day}$), Thunder Bay, 1978.

Station	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
63003	185 Gore Street	.17	.13	.04	.22	.09	.02	.08	.05	.04	.08	.07	.11	.09
63004	24 Mountain Road	.59	.20	.05	.24	-	.06	.09	.07	.09	-	.06	.11	.16
63005	McKellar Hospital	.19	.05	.06	.13	.12	.05	.06	.07	.08	-	.07	.13	.09
63012	Dawson Court	.18	.04	.14	.22	.22	.16	.06	.09	.03	-	.07	.10	.12
63017	521 Memorial Avenue	.17	.07	.11	.20	.24	.17	.09	.17	.16	.11	.07	.07	.14
63018	St. Ignatius School	.13	.05	.10	.24	-	.13	.04	-	-	-	.07	.08	.10
63019	Main Street	.18	.07	.16	.45	.15	.09	.09	.14	.12	-	.08	.10	.15
63020	Hodder Avenue	.13	.05	.13	.24	.19	.17	.07	.08	.07	-	.06	.08	.12
63021	Mission Island	.32	.12	.09	.17	.09	.11	.25	.12	.15	-	.13	.21	.16
63022	St. Joseph's Hospital	.28	.16	.12	.22	.17	.10	.06	.08	.08	-	.08	.11	.13
63040	Ontario Gov't. Building	.17	.05	.06	.19	.17	.08	.07	.14	.08	.08	.04	.10	.10
63046	Montreal Street			.12	-	.21	.07	.16	.12	.14	-	.10	.08	.12
63047	Totem Tourist Court	-	.18	-	.29	.15	.08	.12	.10	.08	.10	.38	.15	.16

TABLE 8. Average sulphation rates ($\text{mg SO}_3/100 \text{ cm}^2/\text{day}$), Thunder Bay, 1973-1978.

Station	Location	1973	1974	1975	1976	1977	1978	Five-year mean
63003	185 Gore Street	.07	.10	.13	.10	.12	.09	.10
63004	24 Mountain Road	.16	.16	.18	.12	.15	.16	.16
63005	McKellar Hospital	.09	.08	.09	.08	.12	.09	.09
63012	Dawson Court	.11	.09	.08	.10	.16	.12	.11
63017	521 Memorial Avenue	.10	.09	.10	.09	.15	.14	.11
63018	St. Ignatius School	.07	.06	.07	.08	.13	.10	.08
63019	Main Street	.24	.11	.13	.15	.28	.15	.18
63020	Hodder Avenue	.10	.10	.10	.08	.14	.12	.11
63022	St. Joseph's Hospital	.14	.12	.11	.10	.15	.13	.12
Average, all stations		.12	.10	.11	.10	.16	.12	

TABLE 9. Distribution of sulphur dioxide readings (pphm^a, hourly averages) at Ministry of the Environment monitoring sites in Thunder Bay, 1978.

Month	Days of data	Number of readings for concentrations of:					Maximum values:	
		0-4	5-10	11-14	15-25	>25	Hour	Day
Station 63012								
Jan	31	735	0	0	0	0	3	0
Feb	28	668	1	0	0	0	5	0
Mar	31	737	2	0	0	0	10	1
Apr	30	712	5	3	0	0	12	1
May	27	663	8	0	2	0	19	2
Jun	29	694	11	0	0	0	10	1
Year	176	4209	27	3	2	0	19	2
Station 63022								
Jul	18	444	0	0	0	0	2	0
Aug	27	641	0	0	0	0	1	0
Sep	30	659	0	0	0	0	1	0
Oct	31	701	0	0	0	0	3	0
Nov	19	469	1	0	0	0	5	0
Dec	31	742	0	0	0	0	0	0
Year	156	3656	1	0	0	0	5	0
Station 63040								
Jan	21	543	0	0	0	0	1	0
Feb	28	670	1	0	0	0	6	1
Mar	27	667	0	0	0	0	2	0
Apr	30	693	10	1	1	0	15	2
May	30	715	8	0	1	0	17	1
Jun	30	714	0	0	0	0	4	1
Jul	31	721	1	0	0	0	8	1
Aug	31	741	0	0	0	0	2	1
Sep	30	720	0	0	0	0	1	0
Oct	30	723	0	0	0	0	4	1
Nov	30	714	0	0	0	0	2	0
Dec	27	666	0	0	0	0	1	0
Year	345	8287	20	1	2	0	17	2

^aParts per hundred million.

TABLE 10. Distribution of sulphur dioxide readings (ppb^a, hourly averages) at Ontario Hydro monitoring sites in Thunder Bay, 1978.

Month	Number of readings for concentrations of:						Maximum values:	
	0-49	50-99	100-149	150-199	200-250	>250	Hour	Day
Station 63023 (Walsh Street)								
Jan	744	0	0	0	0	0	46	12
Feb	598	0	0	0	0	0	29	9
Mar	742	0	0	0	0	0	44	8
Apr	712	5	0	1	0	0	173	13
May	730	8	0	0	1	1	294	24
Jun	694	1	0	0	0	0	50	15
Jul	624	3	0	0	0	0	50	22
Aug	731	2	0	0	0	0	70	13
Sep	594	0	0	0	0	0	40	7
Oct	719	1	0	0	0	0	50	7
Nov	705	0	0	0	0	0	35	10
Dec	739	0	0	0	0	0	23	10
Year	8332	20	0	1	1	1	294	24
Station 63041 (Mt. McKay)								
Jan	647	28	5	2	1	0	200	30
Feb	628	8	1	0	0	0	100	18
Mar	628	1	0	0	0	0	50	5
Apr	210	2	0	0	0	0	70	8
May	633	8	3	1	1	1	370	28
Jun				no data				
Jul	608	1	0	0	0	0	60	5
Aug	722	1	0	0	0	0	50	5
Sep	511	0	0	0	0	0	40	3
Oct	742	2	0	0	0	0	90	9
Nov				no data				
Dec				no data				
Year	5329	51	9	3	2	1	370	30

^aParts per billion.

TABLE 10. Continued.

Month	Number of readings for concentrations of:						Maximum values:	
	0-49	50-99	100-149	150-199	200-250	>250	Hour	Day
Station 63042 (East End)								
Jan	741	2	0	0	0	0	83	18
Feb	151	0	0	0	0	0	48	12
Mar	717	15	0	0	0	0	84	21
Apr	712	3	1	0	0	0	100	15
May	715	2	0	0	0	0	97	16
Jun	715	0	1	0	0	0	147	8
Jul	738	0	0	0	0	0	42	6
Aug	744	0	0	0	0	0	19	7
Sep	720	0	0	0	0	0	22	4
Oct	739	5	0	0	0	0	73	14
Nov	711	2	0	0	0	0	73	18
Dec	720	21	0	0	0	0	95	26
Year	8123	50	2	0	0	0	147	26
Station 63043 (Burwood)								
Jan	744	0	0	0	0	0	17	8
Feb	161	1	0	0	0	0	50	1
Mar	744	0	0	0	0	0	40	4
Apr	718	1	1	0	0	0	110	12
May	704	2	0	0	0	0	83	10
Jun	720	0	0	0	0	0	41	8
Jul	735	1	0	0	0	0	62	14
Aug	190	0	0	0	0	0	17	3
Sep	719	0	0	0	0	0	27	4
Oct	106	0	0	0	0	0	8	1
Nov	Monitoring terminated October 5.							
Dec								
Year	5541	5	1	0	0	0	110	14
Station 63044 (James Street)								
Jan	742	2	0	0	0	0	60	16
Feb	664	1	1	1	0	0	163	15
Mar	665	1	0	0	0	0	57	9
Apr	705	8	2	0	0	0	132	22
May	731	6	3	0	0	0	110	20
Jun	720	0	0	0	0	0	43	6
Jul	723	6	0	0	0	0	69	17
Aug	744	0	0	0	0	0	26	6
Sep	720	0	0	0	0	0	32	4
Oct	739	0	0	0	0	0	34	9
Nov	717	0	0	0	0	0	48	14
Dec	741	0	0	0	0	0	40	12
Year	8611	24	6	1	0	0	163	22

TABLE 11. Distribution of readings of total reduced sulphur (ppb^a, hourly averages) at station 63046, Thunder Bay, 1978.

Month	Days of data	Number of readings for concentrations of:					Maximum values:	
		0-10	11-20	20-27	28-50	>50	Hour	Day
Jan	25	629	4	0	1	0	32	3
Feb	28	648	10	1	2	0	45	7
Mar	23	574	10	3	2	0	43	6
Apr	29	692	10	0	0	0	15	4
May	31	705	26	8	1	0	37	8
Jun	29	657	23	6	4	0	40	7
Jul	28	623	41	13	7	0	43	9
Aug	23	518	24	1	1	0	29	5
Sep	24	552	11	2	3	0	35	6
Oct	18	472	27	1	1	0	29	8
Nov	22	442	75	8	6	0	48	12
Dec	nil	10	3	1	0	0	27	-
Year		6522	264	44	28	0	48	12

^aParts per billion.

TABLE 12. Directional distribution of hourly readings of total reduced sulphur (TRS) in 1978 at station 63046, Thunder Bay.

Wind direction ^a	Number of hours of wind, by direction	Average TRS concentration (ppb ^b)
N	283	0.3
NNE	237	0.2
NE	234	0.4
ENE	390	0.1
E	727	0.1
ESE	211	0.1
SE	56	0.3
SSE	83	0.3
S	256	0.9
SSW	278	3.0
SW	638	6.3
WSW	696	5.0
W	770	2.0
WNW	445	0.4
NW	281	0.2
NNW	217	0.1
Calm	1007	1.9

^aMeasured 10 m above ground at Thunder Bay airport.^bParts per billion.

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